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FINAL REPORT FOR RESEARCH AGREEMENT
#INT-92722-RJVA
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Evaluation of Ground-based Videography as a Tool for Monitoring the Condition of Stream and Riparian Ecosystems

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7 July 1994

Summary

One of the goals of the Fish Research Work Unit is to develop technical tools that can assist National Forest fish biologists in developing sound management practices. These tools are designed to provide the land manager with appropriate information such that management strategies can be developed to maintain the structure and function of stream systems. A visual component of a monitoring program can assist to clearly illustrate the response of a stream to a management activity and can reveal both pronounced and subtle change of the system over time. Such information can be useful in identifying the causes of initial degradation and the actions needed for restoration. This project evaluated the utility and cost of incorporating digital images into a monitoring program as a means of providing pictorial representations of stream channel response to management activities.

Introduction

The National Forest Management Act (1976) and the National Environmental Policy Act (1969) mandate that aquatic resources be monitored on public land to evaluate the effects of land management practices. Because of the need for information rich and cost efficient monitoring tools, this study was designed to evaluate the utility of ground-based, oblique, video images of individual stream habitat units as part of a geographical information system (GIS) database.

Photo-point surveys have been used extensively by the U. S. Forest Service to display physical changes of a site through time and in response to management actions. Photographs have historically been used in conjunction with tabulated data describing physical conditions to achieve a more comprehensive evaluation of an ecological system than might otherwise be possible with numerical data alone. Images can enhance our understanding of the type and scope

of changes that occur as the result of management activities. This permanent, visual component of the monitoring program can provide valuable insights, and may prove especially useful to those managers that lack historical knowledge of a site by providing them with a permanent visual record of the resource at various points in time.

However, a common drawback of photo-point surveys is that photographs are frequently stored and managed in a database physically distinct from the database containing numerical data describing the physical condition of a site. Over time, photographs can be misplaced, misfiled, or lost, an especially common problem when the personnel originally responsible for maintaining files move to new work stations. Even under the best circumstances, the exact geographic location of a photo-point may be unknown thereby compromising our ability to interpret changes in condition within a larger geographic context.

An ideal monitoring program should provide imagery with a precise geographic link and enable any user to readily access and understand the data independent of who has collected and maintained the data records. Although there is no substitute for numerical data, pictorial representations can often characterize complex or diverse objects better than numerical data, i.e., "a picture is worth a thousand words". An image also can assist in translating the meaning of tabular data to those individuals who may not be familiar with a site or who do not have the technical expertise necessary to interpret the data.

Geographic information systems can be used to create and maintain databases containing both numerical and photographic information that are referenced to specific site locations. We believe that GIS will be a powerful tool for monitoring stream channels and their associated riparian vegetation by providing a permanent record of the link between images, numerical data,

and site location. In this report we (1) demonstrate how to integrate digital images into a GIS and (2) evaluate the utility and cost of developing and maintaining a GIS database for monitoring stream habitat and riparian areas. We also compare both the cost and the quality of two sources of imagery: that obtained from a commercially available 8 mm video camera and that from a standard 35 mm camera.

Study Design

Streams and individual reaches were selected for this study that contrasted in management history. Sites ranged from those under heavy grazing pressure from livestock to nearly pristine streams within designated wilderness areas. We examined several pairs of streams that were similar in stream size, geology, climate, vegetative composition, and channel type but differed in channel and riparian condition. We used these paired sites to determine whether videographic imagery could adequately display differences between disturbed and undisturbed streams in both channel morphology (bank undercut, stability, sloughing, wetted and bankfull channel shape) and bank vegetation cover (height, composition, and density).

Methods

A two-person field team sampled several drainages in National Forests of central and southeastern Idaho during the summer of 1992. Sampling sites were located within dominant reach types (Rosgen 1985) and data collected from several of the most common types of fast-water and slow-water habitat units (Hawkins et al., 1993) occuring within each reach. For each habitat unit, we determined its geographic coordinates, collected numerical data describing channel and riparian conditions, and obtained imagery for the site.

Numerical Data

Cross-sectional transects were established for each habitat unit by stretching a measuring tape across a portion of the unit approximately equal to its average width. Measurements for several physical features were taken along this transect line (Table 1).

Table 1. Selected data collected for each cross-sectional transect.

Variable	Description
Habitat type	Class of habitat unit (Hawkins et al., 1993)
Bankfull width	Horizontal distance between the two banks
Wetted width	Horizontal distance between right and left edge of water
Bankfull height	Vertical distance from top of bank to deepest point on transect
Water depth	Depths at each shoreline and at 5 equally spaced intervals along transect.
Bank vegetation height	Height of riparian vegetation on each bank
Overstory	Presence or absence of overstory vegetation
Bank undercut	Depth of undercut, if present, at each bank
Bank stability	Stable or unstable as revealed by cracking, sloughing, and erosion
Video placement	Location (upstream/downstream) and distance of camera from transect
35 mm camera placement	Location (upstream/downstream) and distance of camera from transect
Comments	Unique features, sampling problems, etc.

Imagery

The imagery collected in the field consisted of several minutes of videographic imagery and one 35 mm photographic slide for each unit. The video was shot using Hi8 Metal-E® 8mm tape in a Sony Hi8 Handycam® video camera recorder, housed in a waterproof Sony Handycam® (75

mm) super marine pack. We used an erasable marker board to identify each new habitat in the field (stream name, habitat type, date), and we recorded the pertinent information on the video tape before taping the actual habitat unit.

The video camera was then set up on a tripod in the middle of the stream approximately ten meters from the habitat unit transect line. The camera was positioned either upstream or downstream from the habitat unit, depending on lighting conditions. The actual distance the camera was set up from the habitat unit depended primarily on the cover conditions at the site. In some instances, the vegetation was so thick that the camera was within 5 meters of the habitat unit. Optimally, the camera was set up so that the entire channel was well within the frame as well as some of the upland vegetation community. The shutter speed used on the video camera varied depending upon the lighting conditions, which often dictated a relatively slow speed due to the dark conditions under a thick riparian canopy. The slides were taken from approximately the same position in the stream, and the shutter speed was adjusted for the lighting conditions.

Approximately 30 seconds of imagery was collected without moving the video camera. Thirty seconds of tape was needed to allow adjustments of contrast and color during image processing. In addition to the 30 seconds of stationary imagery, the surrounding area was also panned to document its overall condition and any features of particular interest, such as bank erosion, management activities, and riparian composition.

Image Processing

To use video images in a GIS database, the analog imagery had to be converted to digital format. We used a commercial color video frame grabbing system (ComputerEyes/RT®) to convert the analog video signals to digital format. These images were then saved to floppy disk

for subsequent processing. The minimum system requirements for use with the frame grabbing system we used are described in Appendix A.

Before any imagery was digitized, the video tape was reviewed in its entirety to ensure that the best images were used. Most frame grabbing systems allow the user to view the moving video imagery on the computer screen. When reviewing the tape, we checked the field notes associated with the video information to make sure that no errors were made in the field when labeling the habitat units on the video tape and to make sure that the sequence of habitats on the video followed the sequence in the field books. Pertinent imagery adjacent to and upland from the stream channel was also digitized for inclusion in the database for that habitat unit.

The frame grabbing system we used stored a new image every 1/30th of a second in its on-board memory chips. To digitize the video imagery we first adjusted the image to yield the most usable image, and once the quality was satisfactory we then froze the frame of interest, saved it (digitized) in the graphics card's memory, and paused the camera. We used an image resolution of 640 * 480 pixels with 24 bits per pixel, the maximum resolution provided by the frame grabbing system. The image was then stored on disk in one of several selectable graphics file formats.

We saved images in Tagged Image File Format (TIFF), because the GIS software we used (Arc/Info® and Arcview I®) was documented to support this format. We later converted these files to Erdas® format, because Arcview I® was unable to load the TIFF files created by ComputerEyes/RT®. The Erdas® format proved to be convenient, because the images could then be viewed in both Arcview I® and Erdas®.

The size of each image file at the resolution used is roughly 900K, which therefore required

one high density floppy disk per image. If storage space is limited, the imagery could be digitized at 8 or 16 bits, but such images may not provide sufficient spatial resolution for some uses; additionally, once the resolution is reduced, higher resolution images cannot be retrieved without redigitizing from the original video tape.

After digitizing all images necessary for each stream, images were loaded onto the computer or workstation where the GIS processing was conducted. Due to the digital size of the images, it was most practical to work with no more than 50 images at a time due to typical storage constraints of most hard drives. When each stream was completed, all images and data were stored on tape and removed from the hard disk.

GIS Database Construction

After the imagery and physical data were collected, they were incorporated into an Arc/Info® GIS database. The individual steps that were necessary to create the GIS database included: digitizing relevant information from 7.5' topographic and orthophoto maps, identifying sample locations, importing the imagery, and creating attribute files of numerical data that described the physical conditions present at each sample site.

The watershed boundary, drainage network, and any other features of interest for each stream were digitized as separate database layers. Sample locations were digitized after the stream network was established. Point attribute files of numerical data were referenced to the digitized, watershed features. All data were then checked for errors.

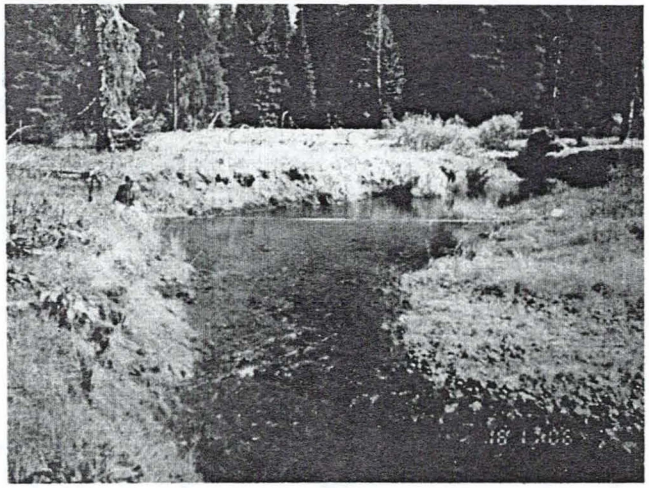
Once all the data layers were compiled, we could view and query the imagery and other data layers in a number of ways. The Arcview I® module of the Arc/Info® software allows users to display and query spatial databases in a graphic environment called a view. The user may open

and display many views at once. For example, the watershed boundary, drainage network and sample stations, images of specific sample stations, and tables of numerical data can all be viewed simultaneously.

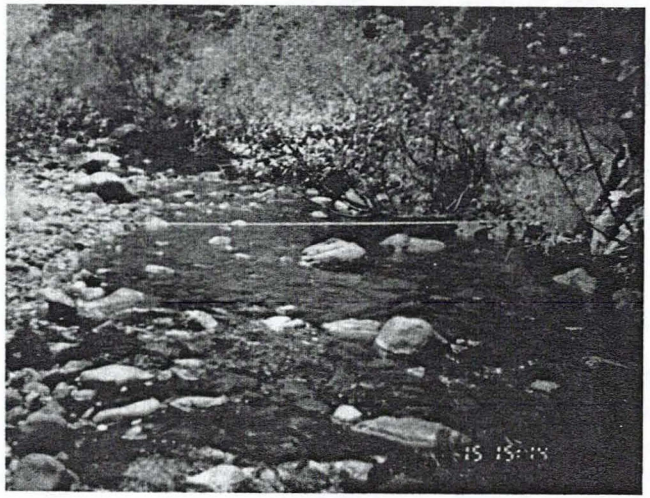
Demonstration of Utility of Approach

We used information from three reaches of Boulder Creek, Idaho to demonstrate the utility of coupling video and numerical data within a GIS (Fig. 1, Table 2). The Boulder Creek drainage was surveyed during August of 1992 and contained both degraded and relatively undisturbed reaches. The differences in condition among these three reaches illustrate how conditions may change at any given site over time in response to different management activities. The three reaches shown here represent low (Reach A), moderate (Reach B), and heavy (Reach C) disturbance associated with lifestock grazing and hence represents a site either in the process of degradation (A $\rightarrow$ C) or restoration (C $\rightarrow$ A).

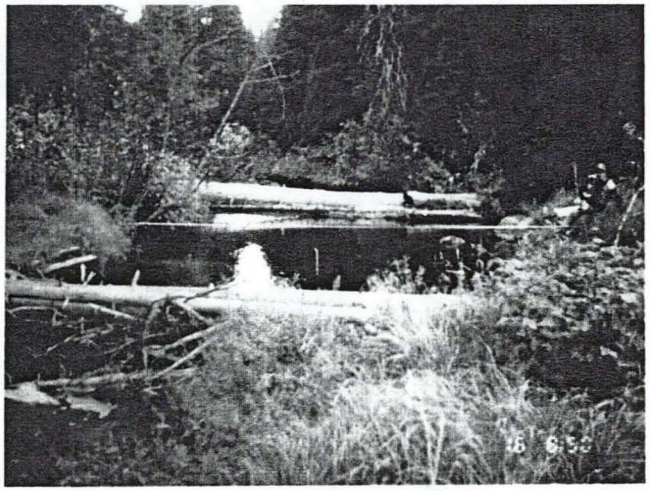
Reach A is indicative of the most desirable condition of stream reaches on National Forest lands. Streambanks were stable and well vegetated and the stream channel contained a complex set of habitat types. Reach B illustrates the condition of a reach experiencing either moderate grazing pressure or having only partly recovered from earlier heavy grazing. Although riparian vegetation was present, much of the streambank was severely eroded, and only lateral scour pools provided habitat for adult trout. Reach C represents a reach in very poor condition. The riparian vegetation had been grazed down to bare soil, the banks were unstable, and only three habitat types existed within the channel. Although both the numerical data (Table 2) and the



R7HAB22



R6HAB17



R6HAB50

Table 2. Selected numerical data describing different aspects of the three sites shown in Figure 1.

Stream	Location Code	Habitat Type	Bankfull Width	Bankfull Height	WD Ratio	Veg Height Right	Veg Height Left	Undercut Right	Undercut Left
Boulder	R7HAB22	LSP	10.1	0.73	13.9	0.25	0.75	0	0
Boulder	R6HAB17	SR	7.8	0.32	24.4	1.00	2.00	0	0
Boulder	R6HAB50	GLD	8.5	0.50	17.0	0.65	0.40	0	0

imagery (Fig. 1) show differences in channel condition between sites, the imagery provides a dramatic visual context in which to clearly understand the meaning of the numerical data.

Costs of Video Imagery Versus Photographs

Although the advantages of a visual record complementing numerical data appear obvious, the relative merits of videographic images versus those available from standard photography are not so obvious. One important difference between the two photographic formats is the amount of data that can be stored on one video tape compared to the number of rolls of film it would take to record the same amount of imagery. With video, the landscape surrounding a location can be recorded on a small amount of film while panning the camera. In contrast, numerous slides would be required to capture the same information.

The combined initial costs of equipment and the costs of processing 120 images is about the same for the two formats (Table 3). However, the initial costs for 35 mm imagery may greatly exceed that for video if something other than a barebones scanner is purchased. Furthermore, once the initial investment in equipment is made, the running costs of processing video imagery is much less than for 35 mm slides: $170 for video versus a minimum of $452 and a maximum of $1,852 for 35 mm slides. The image quality of a scanned, 35 mm slides is technically better than the digitized video image, however the quality of video images is more than adequate for stream monitoring purposes. Considering the number of images video can capture and store and the costs of equipment and processing, videography provides a cost-effective alternative to standard photography.

Table 3. Cost comparison of video and 35 mm imagery. Comparisons are based on minimum equipment costs and the estimated costs of recording and processing 120 images.

35 mm Slides		Video Images	
Item/Service	Cost ($)	Item/Service	Cost ($)
Camera	350	Camera	980
Film	32	Camera housing	720
Slide processing	20	Video digitizer	600
Slide scanner† and	2,000	Video tape	20
Slide scanning†	400	Video processing¶	150
or			
Scanning service‡	1,800		
Total with scanner†	2,802	Total	2,470
Total without scanner‡	2,202		

† Costs of slide scanners may be as high as $10,000. Cost of slide scanning estimated as 120 slides ÷3 slides / hr X $10 / hr of technician time.

‡ Costs of commercial slide scanning service estimated as $15 / slide.

¶ Costs of processing video images estimated as 120 images ÷8 images / hr X $10 / hr of technician time.

References

Digital Vision, Inc. 1992. ComputerEyes/RT owners manual, 2nd edition. Dedham, Ma.

Environmental Systems Research Institute, Inc. 1991. Arc/Info Geographic Information System,
Redlands, Ca.

Erdas, Inc. 1990. Erdas version 7.5. Atlanta, Ga.

Hawkins, C. P., J. L. Kershner, P. A. Bisson, M. D. Bryant, L. M. Decker, S. V. Gregory, D. A. McCullough, C. K. Overton, G. H. Reeves, R. J. Steedman, and M. K. Young. 1993. A hierarchical approach to classifying stream habitat features. Fisheries 18:3-12.

Rosgen, D. L. 1985. A stream classification system. Pages 91-95 in R. R. Johnson, C. D. Ziebell, D. R. Palton, P. F. Ffolliott, and R. H. Hamre (eds). Riparian ecosystems and their management: reconciling conflicting uses. General technical report RM-120, Rocky Mountain Forest and Range Experiment Station, USDA Forest Service, Fort Collins, Colorado.

Appendix A

The minimum system requirements for use with ComputerEyes/RT® are: an IBM® PC/XT/AT/286/386/486 or compatible or PS/2, 25/30; an available expansion slot for the graphics board; a 5.25" or 3.5" floppy disk drive, at least 640K of RAM, version 2.1 or higher of MS DOS or equivalent; a hard disk drive; and a Video Graphics Array (VGA) adapter or PS/2 Multi-Color Graphics Adapter (MCGA) or equivalent. The final system requirement is a video source such as a video camera, camcorder, VCR or any other video source that puts out a standard S-video signal (ComputerEyes® manual p 11-12).